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Kosciusko County, Indiana

Pacific Northwest Environmental Res. Lab.

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

WEBSTER LAKE

KOSCIUSKO COUNTY

INDIANA

EPA REGION V

WORKING PAPER No. 345

WITH THE COOPERATION OF THE

INDIANA STATE BOARD OF HEALTH

AND THE

INDIANA NATIONAL GUARD

APRIL, 1976

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

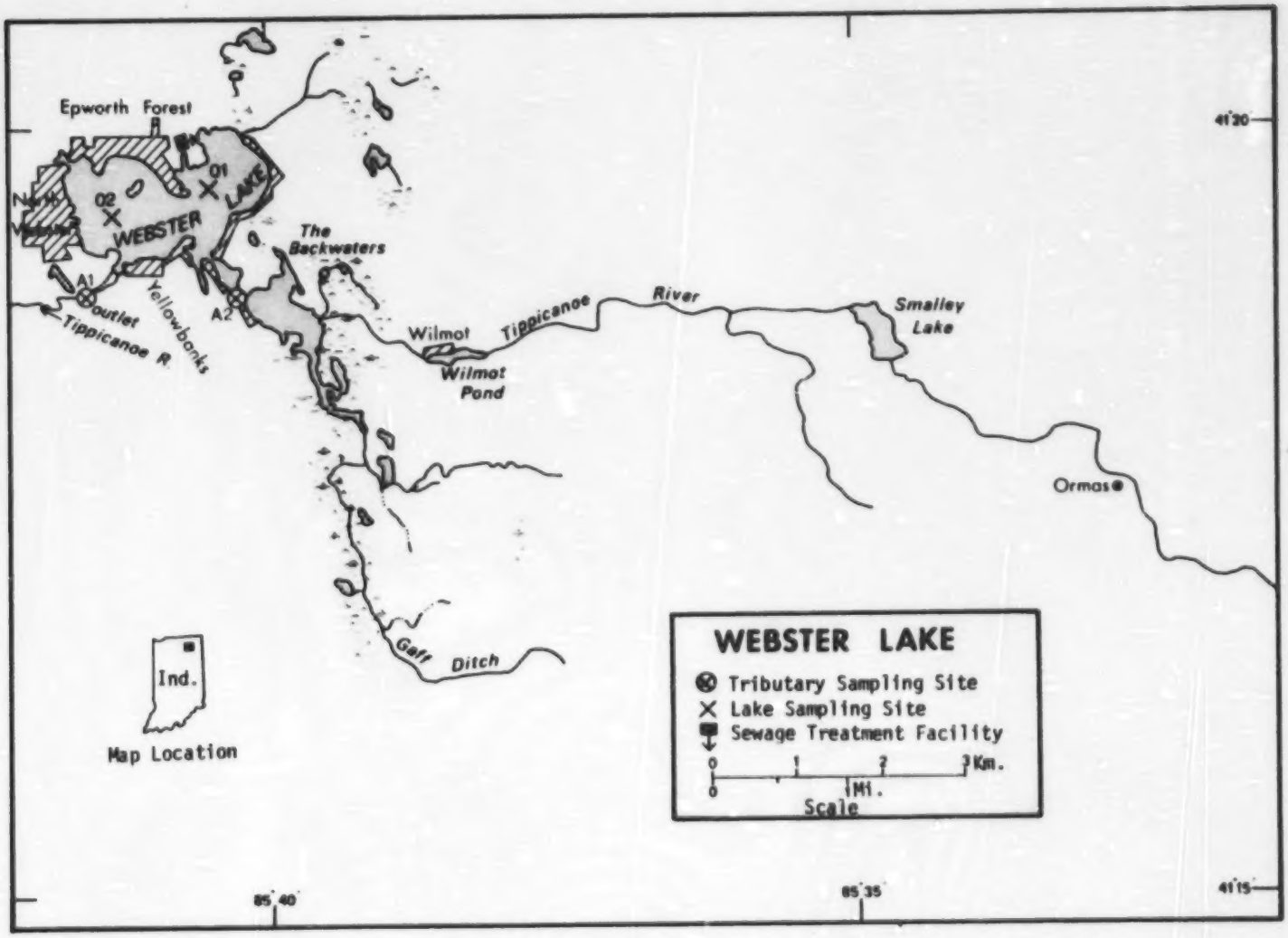
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


Epworth Forest
41°30'
01
LAKE
02
WEBSTER
The Backwaters
A1
Outlet
Tippicanoe R
Yellowbanks
A2
Wilmot
Tippicanoe
River
Smalley Lake
Wilmot Pond
Ormas
Gaff Ditch
Ind.
Map Location
WEBSTER LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
0 1 2 3 Km.
0 1 Mi.
Scale
85°40'
85°35'
41°15'

WEBSTER LAKE

STORET NO. 1837

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Webster Lake is eutrophic. It ranked ninth in overall trophic quality when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Eight of the lakes had less and one had the same median total phosphorus, four had less and three had the same median dissolved phosphorus, ten had less median inorganic nitrogen, 12 had less mean chlorophyll a, and ten had greater mean Secchi disc transparency. Marked depression of dissolved oxygen with depth occurred at station 2 in August and depletion occurred in October.

Survey limnologists observed submerged and emergent macrophytes in the shallows near both sampling stations.

B. Rate-Limiting Nutrient:

The algal assay results indicate phosphorus limitation at the time the sample was collected (05/02/73). The lake data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--The phosphorus contribution of the Epworth Forest Church Camp wastewater treatment plant amounted to an esti-

* See Appendix A.

mated 9.7% of the total reaching Webster Lake during the sampling year. Lakeshore septic tanks were estimated to have contributed 1.6%, but a shoreline survey would be necessary to determine the significance of those sources.

The present phosphorus loading of 1.04 $g/m^2/yr$ exceeds that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11).

Sewage treatment facilities are planned for the Town of North Webster which also will treat wastes from the community on the northeast corner of the lake, including wastes from the Epworth Forest Church Camp (BonHomme, 1976). It is calculated that the elimination of the Camp discharge to the lake will reduce the loading to 0.94 $g/m^2/yr$. While this will still exceed the eutrophic loading, the lake is phosphorus limited, and the reduced phosphorus loading should at least reduce the incidence and severity of nuisance conditions in the lake.

2. Non-point sources--Non-point phosphorus inputs were estimated to have accounted for over 88% of the total load. The Tippecanoe River accounted for 80.4%, and the ungaged drainage areas were estimated to have contributed 6.7%.

The non-point nutrient export of the Tippecanoe River was 17 kg $P/km^2/yr$. This rate compares well with other unimpacted streams studied in this part of Indiana.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 2.37 kilometers^2.
2. Mean depth: 2.1 meters.
3. Maximum depth: 13.7 meters.
4. Volume: 4.977×10^6 m^3.
5. Mean hydraulic retention time: 49 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Tippecanoe River	114.5	1.08
Minor tributaries & immediate drainage -	9.8	0.09
Totals	124.3	1.17

2. Outlet -

Tippecanoe River	126.7**	1.17**

C. Precipitation***:

1. Year of sampling: 79.7 centimeters.
2. Mean annual: 88.5 centimeters.

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† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake; outflow adjusted to equal sum of inflows.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Webster Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at two stations on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 1.5 meters at station 1 and 14.0 meters at station 2.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR WEBSTER LAKE
STORET CODE 1837

PARAMETER	1ST SAMPLING (5/ 2/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 4/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/15/73) 2 SITES RANGE	MEAN	MEDIAN
TEMP (C)	9.9 - 15.4	14.4	15.2	13.1 - 24.9	21.4	23.8	10.6 - 17.6	15.1	17.2
DISS OXY (MG/L)	6.4 - 9.3	8.5	9.0	0.6 - 8.8	4.5	4.4	0.0 - 6.8	3.5	5.2
CNDCTVY (MCROMO)	490. - 520.	502.	500.	379. - 431.	412.	424.	374. - 394.	380.	378.
PH (STAND UNITS)	8.0 - 8.4	8.3	8.4	7.6 - 8.4	8.1	8.3	7.3 - 8.3	7.9	8.0
TOT ALK (MG/L)	195. - 203.	199.	199.	173. - 198.	186.	184.	171. - 248.	197.	175.
TOT P (MG/L)	0.025 - 0.035	0.029	0.028	0.014 - 0.028	0.021	0.021	0.014 - 0.038	0.022	0.019
ORTHO P (MG/L)	0.002 - 0.008	0.004	0.004	0.003 - 0.006	0.005	0.005	0.007 - 0.021	0.011	0.010
NO2+NO3 (MG/L)	0.720 - 0.930	0.844	0.870	0.070 - 0.260	0.134	0.100	0.040 - 0.100	0.070	0.070
AMMONIA (MG/L)	0.060 - 0.220	0.090	0.070	0.060 - 0.330	0.154	0.090	0.130 - 3.450	1.063	0.180
KJEL N (MG/L)	0.700 - 1.100	0.929	1.000	0.930 - 1.100	1.000	1.000	1.200 - 5.600	2.471	1.600
INORG N (MG/L)	0.790 - 1.150	0.934	0.930	0.130 - 0.590	0.288	0.190	0.190 - 3.550	1.133	0.260
TOTAL N (MG/L)	1.590 - 1.870	1.773	1.830	0.970 - 1.260	1.134	1.150	1.260 - 5.700	2.541	1.680
CHLRPYL A (UG/L)	10.0 - 14.9	12.4	12.4	12.6 - 14.3	13.4	13.4	8.5 - 8.7	8.6	8.6
SECCHI (METERS)	1.5 - 1.8	1.7	1.7	------ ----------			1.8 - 1.8	1.8	1.8

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/02/73	1. Synedra sp.	2,553
	2. Cryptomonas sp.	1,343
	3. Asterionella sp.	381
	4. Melosira sp.	336
	5. Dinobryon sp.	224
	Other genera	380
	Total	5,217
08/04/73	1. Microcystis sp.	6,999
	2. Fragilaria sp.	986
	3. Cyclotella sp.	789
	4. Scenedesmus sp.	740
	5. Synedra sp.	641
	Other genera	3,843
	Total	13,998
10/15/73	1. Microcystis sp.	1,799
	2. Synedra sp.	642
	3. Cosmarium sp.	492
	4. Dictyosphaerium sp.	471
	5. Cyclotella sp.	428
	Other genera	2,485
	Total	6,317

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
05/02/73	1	14.9
	2	10.0
08/04/73	1	14.3
	2	12.6
10/15/73	1	8.7
	2	8.5

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.820	0.1
0.050 P	0.055	0.820	12.2
0.050 P + 1.0 N	0.055	1.820	16.2
1.0 N	<0.005	1.820	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Webster Lake was low at the time the assay sample was collected. The significant increase in yield when only orthophosphorus was added indicates phosphorus limitation. Note that the addition of nitrogen alone did not result in an increase in yield compared to the control yield. Based on these results, phosphorus limitation is indicated.

The lake data also indicate phosphorus limitation; the mean inorganic nitrogen/orthophosphorus ratios were 58/1 or greater at all sampling times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2, in $kg/km^2/year$, and multiplying by the ZZ area in km^2.

The operator of the Epworth Forest wastewater treatment plant provided monthly effluent samples but no flow data; nutrient loads were estimated at 0.567 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day. Note that the estimate of phosphorus loading was reduced by 50% to adjust for the Indiana phosphate detergent ban in effect since January, 1972.

* See Working Paper No. 175.

A. Waste Sources:

1. Known domestic -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Epworth Forest Church Camp	425*	tr. filter	160.9	Webster Lake

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	1,990	80.4
b. Minor tributaries & immediate drainage (non-point load) -	165	6.7
c. Known domestic STP's -		
Epworth Forest	240	9.7
d. Septic tanks** -	40	1.6
e. Known industrial - None	-	-
f. Direct precipitation***	40	1.6
Total	2,475	100.0

2. Outputs -

Lake outlet - Tippecanoe River 1,250

3. Net annual P accumulation - 1,225 kg.

* Adjusted yearly population.
** Estimate based on 295 shoreline dwellings; see Working Paper No. 175.
*** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	107,365	86.8
b. Minor tributaries & immediate drainage (non-point load) -	9,190	7.4
c. Known domestic STP's -		
Epworth Forest	1,445	1.2
d. Septic tanks* -	3,145	2.5
e. Known industrial - None	-	-
f. Direct precipitation** -	2,560	2.1
Total	123,705	100.0

2. Outputs -

Lake outlet - Tippecanoe River 94,115

3. Net annual N accumulation - 29,590 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
Tippecanoe River	17	938

* Estimate based on 295 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.04	0.52	52.2	12.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Webster Lake:	
"Dangerous" (eutrophic loading)	0.78
"Permissible" (oligotrophic loading)	0.39

V. LITERATURE REVIEWED

BonHomme, Harold L., 1976. Personal communication (planned waste treatment facilities at North Webster). IN Div. of Water Poll. Contr., Indianapolis.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Dept. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAHACT LAKE	0.058	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.004
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.008
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1824	MONROE RESERVOIR	0.025	0.325	438.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLER LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.409	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.257	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.284	1.920	442.667	16.100	15.000	0.150
1855	PIGEON LAKE	0.058	1.945	442.667	11.900	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.018

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SDD-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MONSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	65 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	NOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROORED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITMER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1837 WEBSTER LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 127.4

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1837A1	127.7	1.59	1.65	2.58	2.43	1.58	1.19	0.73	0.28	0.25	0.27	0.63	1.13	1.21
1837A2	114.5	1.42	1.65	2.32	2.18	1.42	1.07	0.65	0.25	0.23	0.24	0.56	1.02	1.08
1837ZZ	9.8	0.110	0.139	0.204	0.190	0.119	0.093	0.054	0.016	0.016	0.017	0.048	0.093	0.091

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 127.4
SUM OF SUB-DRAINAGE AREAS = 124.3

TOTAL FLOW IN = 14.11
TOTAL FLOW OUT = 14.52

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1837A1	6	73	2.350	9	3.256				
	7	73	0.680	14	0.340				
	8	73	0.566	11	0.396				
	9	73	0.122	15	0.096				
	10	73	0.119	13	0.065				
	11	73	0.283	6	0.142				
	12	73	1.019	15	0.906				
	1	74	2.605	19	1.359				
	2	74	3.115	2	3.964	16	1.982		
	3	74	3.738	2	2.775	16	3.964		
	4	74	2.209	13	2.209				
	5	74	1.756	19	2.152				
1837A2	6	73	2.528	9	2.322				
	7	73	0.510	14	0.283				
	8	73	0.481	11	0.340				
	9	73	0.099	15	0.079				
	10	73	0.096	13	0.054				
	11	73	0.266	6	0.119				
	12	73	0.906	15	0.765				
	1	74	2.322	19	1.189				
	2	74	2.718	2	3.398	16	1.812		
	3	74	3.398	2	2.435	16	3.398		
	4	74	1.926	13	0.793				
	5	74	1.671	19	0.708				
1837ZZ	6	73	0.217	9	0.198				
	7	73	0.044	14	0.024				
	8	73	0.041	11	0.028				
	9	73	0.008	15	0.007				
	10	73	0.008	13	0.005				
	11	73	0.023	6	0.010				
	12	73	0.078	15	0.065				
	1	74	0.200	19	0.102				
	2	74	0.234	2	0.283	16	0.156		
	3	74	0.292	2	0.210	16	0.283		
	4	74	0.166	13	0.057				
	5	74	0.144	19	0.059				

STORET RETRIEVAL DATE 76/03/30

183701
41 19 43.0 085 40 28.0 3
WEBSTER LAKE
18085 INDIANA
051792

11EPALES 2111202
0007 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	16	10 0000	15.3		60	490	8.40	203	0.070	1.100	0.720	0.004
	16	10 0005	15.3	9.0		490	8.60	201	0.080	1.100	0.750	0.008
73/08/04	11	00 0000	24.1	8.8		480	8.40	173	0.090	1.100	0.100	0.004
73/10/15	09	20 0000	17.3	6.0	72	375	8.40	175	0.180	1.600	0.080	0.007
	09	20 0004	17.3			375						

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	16	10 0000	0.035	14.9
	16	10 0005	0.030	
73/08/04	11	00 0000	0.027	14.3
73/10/15	09	20 0000	0.023	8.7

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

103702
41 19 31.0 085 41 10.0 3
WEBSTER LAKE
18085 INDIANA
051792

11EPALES 2111202
0044 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/02	16 30	0000	15.4		72	500	8.40	200	0.060	1.000	0.070	0.004
	16 30	0004	15.2	9.3		500	8.40	195	0.060	1.000	0.060	0.004
	16 30	0015	15.2	9.3		500	8.30	196	0.070	0.700	0.090	0.002
	16 30	0025	14.6	8.6		520	8.00	196	0.070	0.700	0.090	0.002
	16 30	0040	9.9	6.4		515	8.00	139	0.220	0.900	0.930	0.003
73/08/04	11 15	0000	24.9			431	8.40	182	0.080	1.000	0.090	0.004
	11 15	0005	23.8	7.4		424	8.30	184	0.060	0.900	0.070	0.005
	11 15	0015	21.0	1.4		425	7.60	191	0.210	1.000	0.150	0.005
	11 15	0024	13.1	0.6		379	7.60	198	0.330	1.000	0.260	0.003
73/10/15	09 40	0000	17.6	6.8	72	374	8.30	172	0.150	1.300	0.080	0.012
	09 40	0015	17.5	6.6		375	8.30	171	0.130	1.200	0.060	0.009
	09 40	0022	17.2	5.2		380	8.20	173	0.180	1.300	0.060	0.010
	09 40	0029	12.1	0.0		383	7.60	204	1.550	2.700	0.070	0.008
	09 40	0035	11.3	0.0		382	7.50	230	1.800	3.600	0.040	0.010
	09 40	0046	10.6	0.0		394	7.30	248	3.450	5.600	0.100	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/02	16 30	0000	0.028	10.8
	16 30	0004	0.030	
	16 30	0015	0.028	
	16 30	0025	0.025	
	16 30	0040	0.025	
73/08/04	11 15	0000	0.016	12.6
	11 15	0005	0.021	
	11 15	0015	0.028	
	11 15	0024	0.014	
73/10/15	09 40	0000	0.018	8.5
	09 40	0015	0.019	
	09 40	0022	0.038	
	09 40	0029	0.019	
	09 40	0035	0.014	
	09 40	0046	0.025	

STORET RETRIEVAL DATE 76/03/30

1837A1
41 19 05.0 085 41 32.0 4
TIPPECANOE RIVER
18 7.5 N WEBSTER
O/WEBSTER LAKE 051792
HWY 13 BRDG .4 SE OF N WEBSTER
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	12 25		0.336	2.700	0.061	0.005K	0.020
73/07/14	07 00		0.031	1.320	0.027	0.005K	0.030
73/08/11	10 05		0.110	1.200	0.082	0.009	0.025
73/09/15	13 40		0.039	1.100	0.028	0.005K	0.020
73/10/13	10 15		0.600	1.080	0.140	0.007	0.035
73/11/06	12 42		0.100	1.200	0.260	0.008	0.020
73/12/15	09 15		0.276	0.900	0.160		0.025
74/01/19	14 25		0.792	0.800	0.160	0.005K	0.020
74/02/02	10 45		2.200	0.900	0.075	0.010	0.050
74/02/16	10 20		1.920	1.200	0.085	0.010	0.045
74/03/02	08 55		2.000	2.300	0.025	0.010	0.065
74/03/16	08 37		1.430	1.200	0.030	0.005K	0.035
74/04/13	09 13		1.300	1.300	0.020	0.005	0.030
74/05/19	13 45		0.580	3.000	0.130	0.010	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED

APPENDIX E

TRIBUTARY and WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/03/30

1837A2
41 19 05.0 085 40 15.0 4
TIPPECANOE RIVER
18 7.5 N WEBSTER
I/WEBSTER LAKE 051792
550 N RD BRDG 1 MI E OF HWY 13
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	12	15	0.820	2.050	0.115	0.022	0.055
73/07/14	06	55	0.018	1.260	0.065	0.017	0.045
73/08/11	10	00	0.016	2.520	0.097	0.011	0.055
73/09/15	13	30	0.010K	1.890	0.044	0.046	0.145
73/10/13	10	30	0.026	1.380	0.132	0.012	0.070
73/11/06	12	37	0.160	1.550	0.080	0.008	0.045
73/12/15	08	40	0.504		0.060	0.012	0.040
74/01/19			0.990	0.800	0.140	0.008	0.035
74/02/02	10	50	2.760	1.000	0.050	0.025	0.060
74/02/16	10	15	2.100	1.500	0.050	0.010	0.045
74/03/02	08	50	2.100	2.700	0.055	0.010	0.060
74/03/16	08	35	2.000	1.600	0.050	0.020	0.060
74/04/13	09	10	1.400	1.400	0.025	0.005	0.037
74/05/19	13	30	0.600	5.000	0.065	0.040	0.360

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

183721 TF183721 P000530
41 20 00.0 085 40 35.0 4
EPWORTH FOREST
18 7.5 N WEBSTER
D/WEBSTER LAKE 051792
WEBSTER LAKE
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
73/06/20	19 30		7.400	6.000	0.165	2.300	2.700		
73/08/15	08 00		1.050	15.000	1.890	2.700	7.000		
73/09/13			8.650	0.460	0.061	3.400	3.600		
73/10/16	10 00		8.100	0.550	0.056	2.500	3.000		
73/11/15	09 30		11.000	0.500K	0.060	2.962	3.050		
74/05/17	09 00		4.500	1.000K	0.170	0.940	1.250		
74/06/20	07 30		12.000	6.300	0.170	2.618	3.450		
74/07/19	07 30		2.080	25.000	0.650	4.300	6.300		
74/08/15	08 15		6.800	31.000		3.900	8.600		
74/09/19	09 00		9.900	1.250	0.025	4.400	4.700		

K VALUE KNOWN TO BE
LESS THAN INDICATED